

THE FIRST ENDEMIC TROGLOBITIC CARABID BEETLES IN HAWAIIAN LAVA TUBES (COLEOPTERA: CARABIDAE)

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Abstract.—The first troglobitic Hawaiian carabid beetles are described from lava tube caves on Haleakalā, Maui Island. The species—*Atelothrus howarthi* Samuelson & Liebherr, NEW SPECIES, and *Atelothrus aae* Samuelson & Liebherr, NEW SPECIES—are members of the tribe Platynini, subtribe Platyni, a group that has radiated extensively on the islands. Both cave species are members of a complex of *Atelothrus* species found on the windward slopes of Haleakalā, but they do not appear to be sister species, suggesting that they represent two independent colonizations of the lava tube habitat.

Key Words.—Insecta, Coleoptera, Carabidae, Platynini, *Atelothrus*, Hawaii, caves

The Hawaiian Carabidae make up the largest assemblage of beetles endemic to the Hawaiian Islands, and are perhaps the largest predaceous insect group to have radiated in the islands (Zimmerman 1948). Of these, the Platynini (= Anchomenides of Sharp) has speciated extensively, resulting in description of 111 species in 23 genera (Sharp 1903, Perkins 1917, Csiki 1931). In recent years, F. G. Howarth of Bishop Museum has investigated the arthropods of Hawaiian lava tubes. The species described below come from dark zones of lava tubes in the upper reaches of Kipahulu Valley, on the eastern part of East Maui Island.

Sharp (1903) established genera for the Hawaiian platynines based on the configuration of the metathoracic flight-wings and pronotal setation. He was aware that setal presence was highly variable within some species, and that “contemporary members of one generation may possibly belong to two different genera, though having the same specific parentage” (Sharp 1903: 177). Thus it is likely that comprehensive cladistic analysis will result in synonymization of many generic names in this fauna. The two cave species we describe appear related to a complex of five epigeal species on East Maui: *Atelothrus erro* (Blackburn), *A. dyscoleus* Sharp, *A. gracilis* Sharp, *A. longicollis* Sharp, and *A. politus* Sharp. The two new species do not appear to be sister taxa, supporting the hypothesis that cave colonization by platynine carabids occurred at least twice on East Maui.

MATERIALS AND METHODS

Specimens were relaxed in warm soapy distilled water before dissection. For males, the intersegmental membranes posterad the apical visible abdominal segment were cut, and the male terminalia extracted. The aedeagus and associated sclerites of abdominal segment IX were placed in cold 10% KOH overnight, acidified with dilute acetic acid, and examined. The aedeagal internal sac was everted while the dissection was in the acetic acid wash. The disassociated ae-

deagus and abdominal sclerites were then placed in glycerin for microscopic examination, thereafter stored in glycerin microvials under the specimens.

For females, the abdomen was removed from water-relaxed specimens and placed overnight in cold 10% KOH. After clearing, the abdominal tergites for segments I–VII were removed along the pleural sutures, and the remaining segments removed from the visible sternites I–VI. The alimentary canal, defensive glands, and reproductive structures were placed in Chlorazol Black® in methyl cellosolve. The defensive glands and associated sclerites of segment VIII were removed, and the reproductive tract and alimentary canal mounted ventral side upward on a temporary glycerin mount. Reproductive structures were examined at $\times 100$ to $\times 400$ using phase-contrast microscopy. All internal cuticular structures were subsequently placed in plastic glycerin vials and stored with the specimens.

Body length is the sum of three dimensions: median length of head from anterior margin of labrum to cervical collar, median length of pronotum, and distance from basal groove of scutellum to apex of left elytron.

Each description is accompanied by a diagnosis sufficient to differentiate the species from all other species assignable to *Atelothrus* sensu Sharp (1903).

ATELOTHRUS HOWARTHI SAMUELSON & LIEBHERR, NEW SPECIES

Type Material. — Holotype (male): HAWAIIAN ISLANDS. (E) MAUI I: Haleakalā National Park, Kipahulu Valley, West Camp, 1800 m [6100 ft], in dark zone of Luamanuiwi Lava Tube, from top of large talus slope at end of lava tube, 14 Jul 1983, F. G. Howarth. The holotype is deposited in the B. P. Bishop Museum, Honolulu (BPBM type no. 14,799). Allotype (female): same data (except 15 Jul 1983) and deposition as holotype. Paratype (female): same data (except Jul 1983) and deposition as holotype; paratype (male): same data (except 4 Mar 1984) and deposition as holotype.

Description. — *Head*: form narrow, elongate, eyes flat, facets barely protruding from genal region of head; neck constricted laterally, obsoletely constricted dorsally. Mandibles elongate, apex finely acuminate. Labrum broadly emarginate medially; six setae along anterior margin, the two outer pairs stout, long, and set in foveate articulatory sockets, the inner pair much finer, shorter, and set in fine sockets. Maxillae elongate; laciniae narrow, acuminate; galeae elongate, apical segment bowed mesally; palps glabrous; palpomere IV fusiform, apex with small flat area. Ligula broad apically, bisetose; second palpomere anteriorly bisetose. Basal three antennomeres with very short microsetae on surfaces ($\times 125$); antennomeres IV–XI elongate, antennomere IV with length $4.40\times$ greatest width. Mentum with bifid or broadly emarginate median tooth; depressions of mentum deep, a round fovea evident at deepest part; submentum with inner and outer pairs of lateral setae present. Eyes reduced, maximal diameter from lower anterior to dorsal posterior margins crossing 12 facets (Fig. 3). Clypeus transverse, width $2.50\times$ length; one seta each side about middle of length. Frons with shallow broad frontal grooves; two supraorbital setae each side, anterior setae above median dimension of eye, posterior just anterad constriction of neck. *Prothorax*: pronotum rhadiniform, lateral margin anteriorly convex before broadly concave and raised basolateral margin, basal margin broadly concave meeting nearly right, bluntly rounded hind angles; median base with slight longitudinal wrinkles, basal marginal bead absent; median longitudinal impression fine; anterior transverse depression deep medially, becoming obsolete one-quarter distance to front angles; area anterad anterior transverse depression weakly longitudinally strigose; anterior marginal bead present just inside front angles, absent medially; front angles narrowly rounded and slightly forward-projecting; lateral marginal depressions broad anteriorly, narrowest at lateral setae, and wider toward hind angles; laterobasal depressions deep, broad, with rounded depression mesad hind seta; lateral marginal seta normally single, unilaterally doubled on right side of female paratype. Prosternal projection narrowly rounded at apex, with a broad marginal bead weakly indicated by a slightly depressed area between procoxae. *Elytra*: lateral margins broadly curved from humerus to weakly developed subapical sinuation; disc flattened medially; basal groove

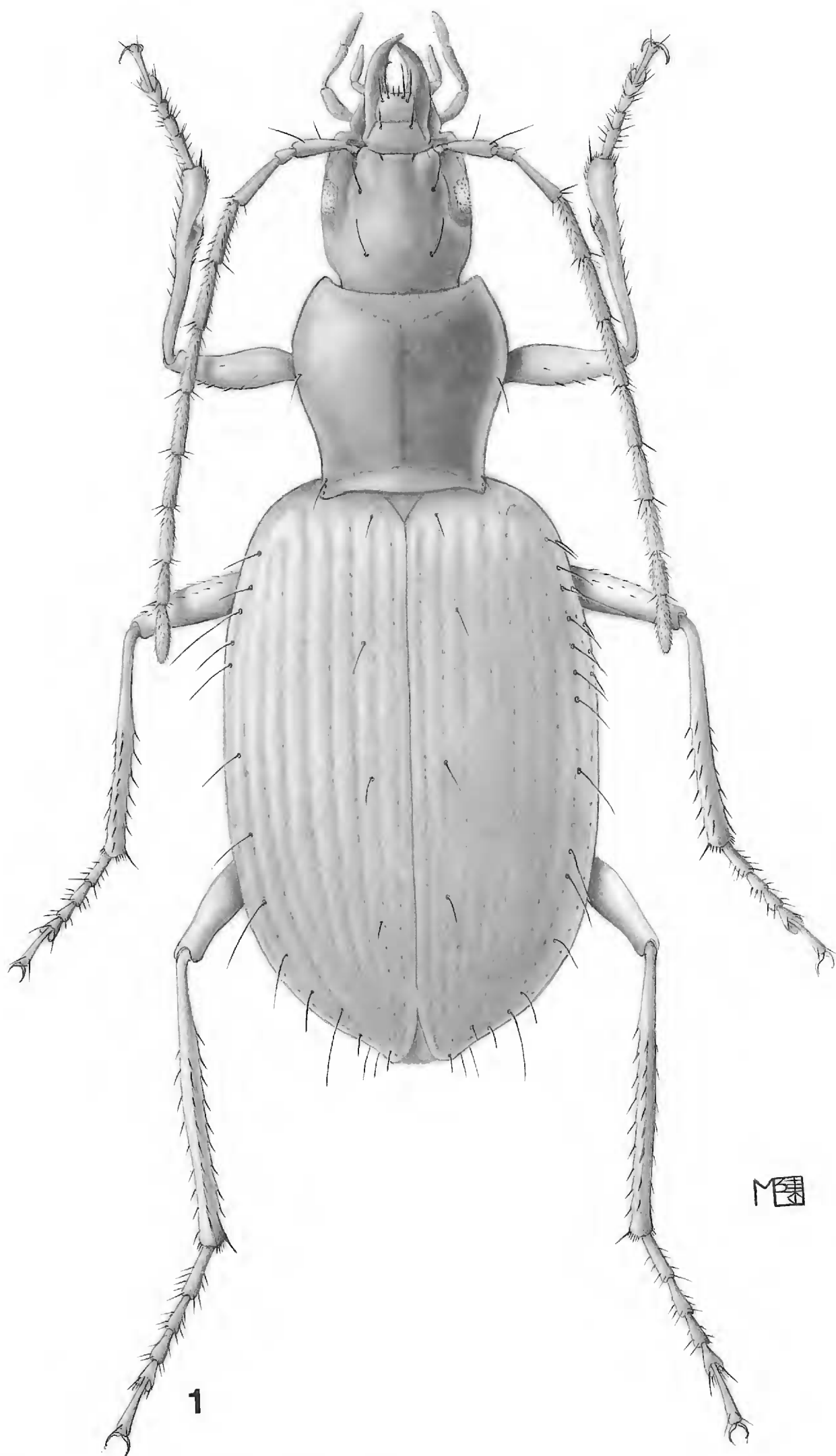
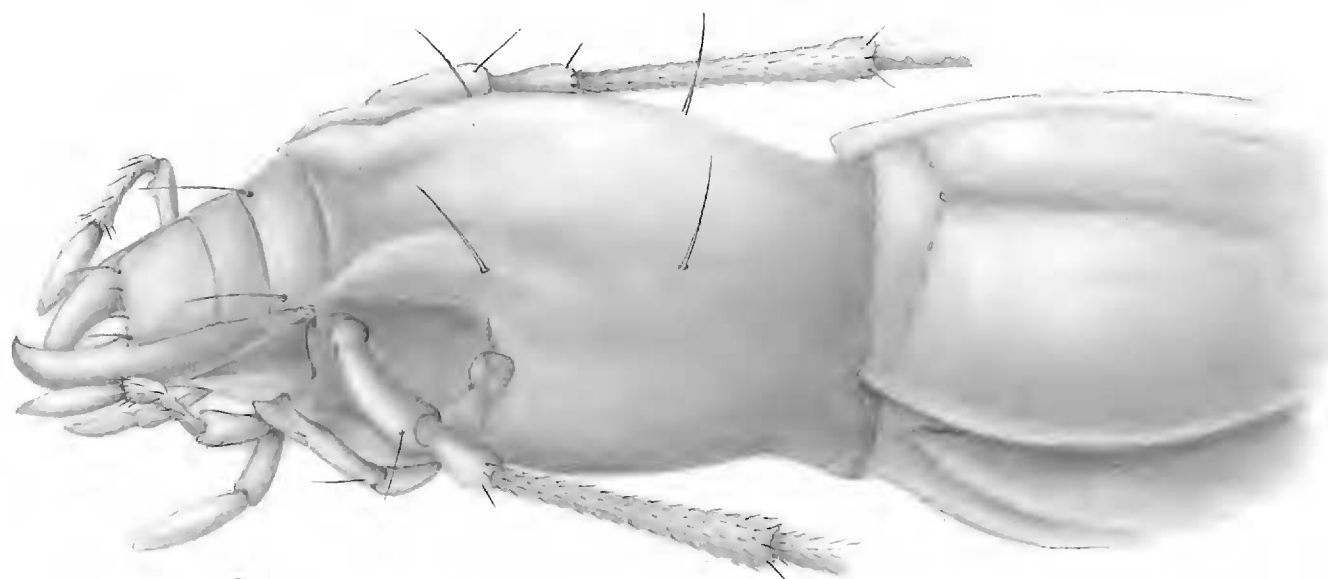
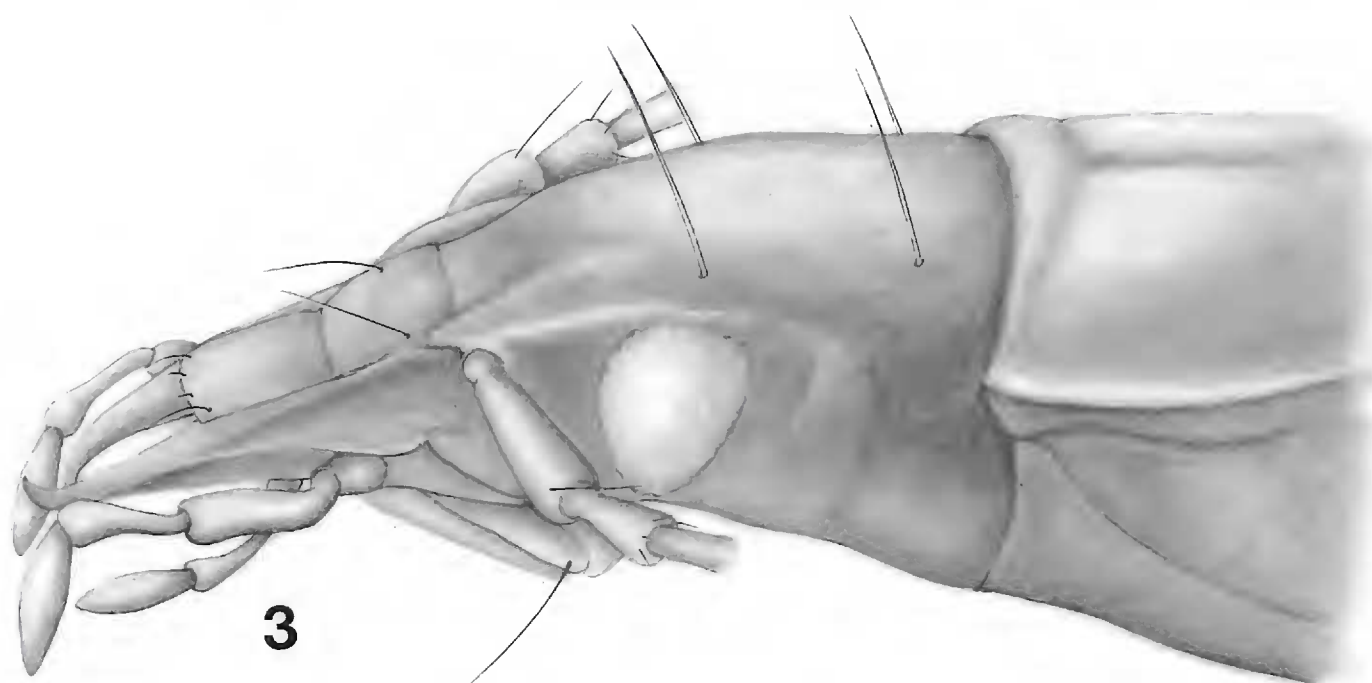


Figure. 1. *Atelothrus howarthi*, female allotype.



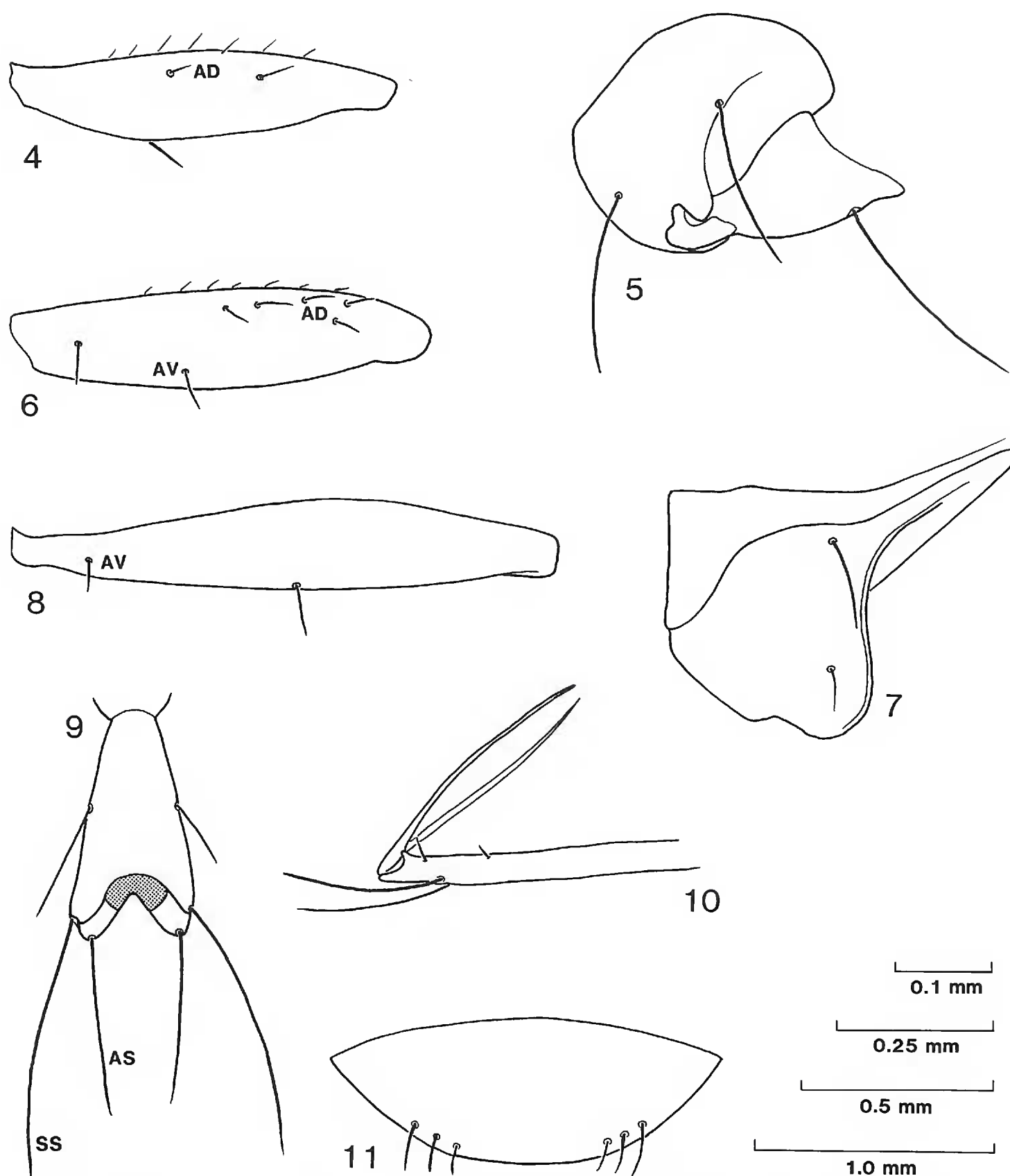
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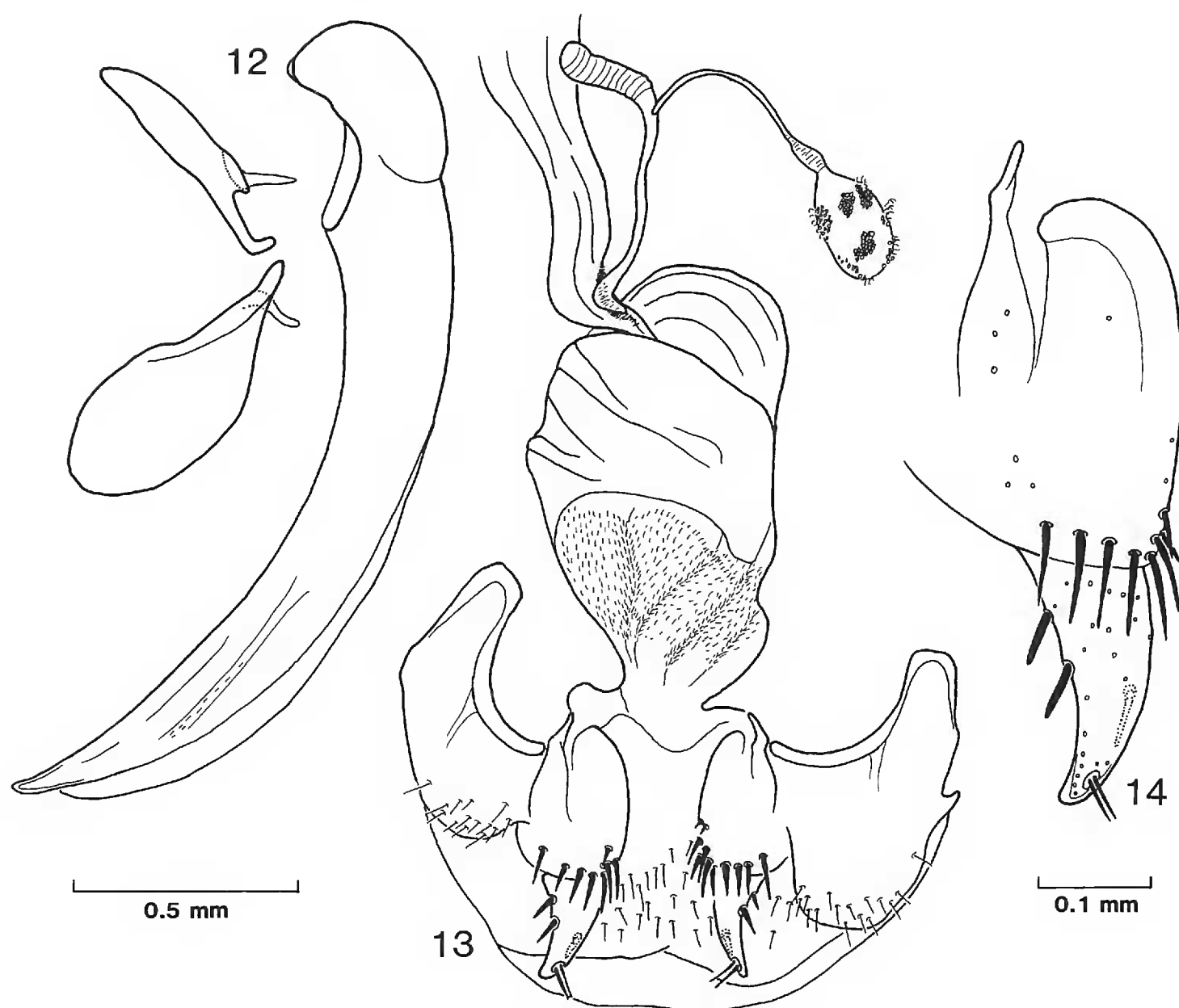
Figures. 2–3. Lateral view of head capsule showing development of compound eye. Figure 2. *Atelothrus aae*. Figure 3. *Atelothrus howarthi*.

straight from second to fourth stria, recurved anteriorly from fourth stria outward, evenly rounded at humerus; striae continuous, slightly wavering, giving the impression of faint punctulae; intervals moderately and broadly convex; scutellar seta present; three dorsal elytral setae in third interval, the anterior seta in medial half of interval, the posterior two in second stria; 12 to 14 setae along lateral margin from humerus to subapical sinuation; a single seta near apex of seventh stria inside subapical sinuation; a single seta at elytral apex posterad second stria; sutural apex rounded. *Pterothorax*: metepisternum slightly elongate, lateral margin $1.25\times$ length of anterior margin; hind wings vestigial, scalelike flaps about as long as metepisterna. *Legs*: profemur with a single ventral seta and two anterodorsal setae (Fig. 4), approximately seven smaller setae along dorsal surface; posterior surface glabrous. Mesocoxa with one ridge seta and one ventral seta (Fig. 5); mesofemur with two anteroventral setae, four to five anterodorsal setae, and about seven smaller dorsal setae (Fig. 6). Metacoxa bisetose, inner seta absent (Fig. 7); metafemur with two anteroventral setae, apex glabrous (Fig. 8); basal three metatarsomeres with sharp keellike median carina and broad internal and external dorsal sulci; fourth metatarsomere smooth, glabrous dorsally, with inner and outer mediolateral, subapical, and apical setae (Fig. 9); apical margin medially emarginate, inner and outer apical lobes equally elongate; metapretarsus with two pairs of short ventral setae and longer apicolateral setae (Fig. 10). *Abdomen*: apical margin of last visible abdominal sternite with one (holotype) or two (paratype) setae each side in males, three marginal setae each side in females (Fig. 11). *Microsculpture*: vertex with evident isodiametric mesh, stronger along upper margins of eyes. Pronotal disc with lightly impressed transverse mesh connected by weak crosslines, the surface faintly alutaceous; laterobasal depressions and



Figures. 4–11. *Atelothrus howarthi*. Figure 4. Left profemur (anterior view). Figure 5. Left mesocoxa and trochanter (anteroventral view). Figure 6. Left mesofemur (anterior view). Figure 7. Left metacoxa (ventral view). Figure 8. Left metafemur (anterior view). Figure 9. Right fourth metatarsomere (dorsal view, fifth tarsomere articulatory socket stippled). Figure 10. Left metapretarsus and claws (outer lateral view). Figure 11. Apical visible abdominal sternite of female (ventral view). Scale bar for Figs. 4, 6, 8, 11, 1.0 mm; for Fig. 7, 0.5 mm; for Figs. 5 and 10, 0.25 mm; for Fig. 9, 0.1 mm. AD = anterodorsal setae; AS = apical setae; AV = anteroventral setae; SS = subapical setae.

median base with granulate isodiametric mesh. Elytral intervals with faintly developed isodiametric mesh, more well developed in lateral intervals. Abdominal sternites with regular transverse mesh, mesh more isodiametric near lateral margins and laterad metacoxae. *Color*: vertex rufobrunneous to rufopiceous; anterior of frons, clypeus, and labrum rufous with testaceous cast; palps and antennae testaceous. Pronotum rufous to rufobrunneous, distinctly lighter in color than vertex; apical and lateral margins and laterobasal depressions more testaceous. Elytra rufotestaceous, thin, translucent. Pronotal



Figures. 12–14. *Atelothrus howarthi*. Figure 12. Male aedeagal median lobe and disassociated parameres (dorsal view for median lobe; ventral view of ventral (= right) paramere shown above dorsal view of dorsal (= left) paramere). Figure 13. Female external genitalia and reproductive tract (ventral view). Figure 14. Right gonocoxa (ventral view; dorsal ensiform seta on apical gonocoxite shown stippled). Scale bar for Figs. 12 and 13, 0.5 mm; for Fig. 14, 0.1 mm.

and elytral epipleura testaceous, venter of body rufous. Coxae, trochanters, and femora testaceous; tibiae and tarsi brunneous. *Body Size*: male holotype and female allotype 7.5 mm body length; male paratype 7.9 mm length; female paratype 8.0 mm length. *Male Genitalia*: aedeagus lightly melanized, testaceous to brunneous; ventral (= right) paramere narrow with subparallel sides (Fig. 12); dorsal (= left) paramere slightly longer and more rounded apically; median lobe slender, elongate, evenly curved, the apex finely acuminate; sagittal crest of basal bulb extremely small to absent; internal sac with inconspicuous microtrichia. *Female Reproductive Tract*: bursa copulatrix elongate with medial band of simple luminal microtrichia (Fig. 13). Spermatheca tubular with short duct; spermathecal gland duct short, joining base of spermathecal reservoir. Hemisternite IX with setose lateral margin, 14–16 setae laterad basal gonocoxite. Basal gonocoxite with apical fringe of 8 to 11 setae (Figs. 13 and 14). Apical gonocoxite moderately stout with two lateral and one dorsal ensiform setae, and apical depression bearing two nematiform setae.

Diagnosis. —Pronotum with two lateral setae, one at middle, the other before hind angle (Fig. 1); hind wings vestigial; mandibles elongate, narrow apically; eyes reduced, surface barely protruding from flattened lateral areas of head; basal groove of elytra anteriorly recurved at humerus, humerus rounded; female with three marginal setae each side on apical visible abdominal sternite (Fig. 11).

Etymology.—This species is named to honor Frank Howarth and his many contributions to the knowledge of Hawaiian cave animals.

Related Species.—Sharp (1903) placed only two species in the genus *Platynus*, basing placement in that taxon on possession of dorsally bisulcate tarsomeres and bisetose pronotal lateral margins. These include *P. ambiens* Sharp from Kauai and *P. calathiformis* Sharp from Maui. The former character diagnoses the five genera Sharp proposed as his Division II of the Hawaiian Platynini. We discount the latter character for inclusion of any Hawaiian species in the Holarctic *Platynus*, due to the plasticity of pronotal setal presence and absence throughout the Platynini (e.g., Liebherr 1988). Such a decision follows Perkins' (1920) opinion that the two species placed in *Platynus* by Sharp are not closely related. We hypothesize that *A. howarthi* is most closely related to *A. longicollis*, a species found in Kipahulu Valley from 900 to 1900 m (A. C. Medeiros, Jr., and J. K. Liebherr, unpublished data), and ranging westward on the windward side of Haleakalā to Waikamoi Gulch. *Atelothrus longicollis* and *A. howarthi* share the derived states of: basolateral pronotal margin concave with hind angles projecting posterad; body pale with elytra translucent; metacoxae bisetose, inner seta lacking; apical margin of apical abdominal segment with three setae each side in female. This hypothesis interprets lateral pronotal setal presence in *A. howarthi* as an autapomorphy, and setal absence in related *Atelothrus* as the primitive state. *Atelothrus howarthi* exhibits developmental plasticity at this setal position—the female paratype has two setae on the right side, and a single seta on the left.

Material Examined.—See type material.

ATELOTHRUS AAE SAMUELSON & LIEBHERR, NEW SPECIES

Type Material.—Holotype (female): HAWAIIAN ISLANDS. (E) MAUI I: Haleakalā National Park, Kipahulu Valley, West Camp, 1830 m [6000 ft], in dark zone of Pukamoa Lava Tube, under stone on mud bank above stream, 29 Apr 1988, F. G. Howarth. The holotype is deposited in the B. P. Bishop Museum, Honolulu (BPBM, type no. 14,800).

Description.—*Head*: vertex convex, domelike; lateral surfaces of head evenly convex from strong neck constriction to eyespot; constriction of neck broad, visible in lateral view. Mandibles moderately elongate, terebral surface broad, apex acuminate. Labrum trapezoidal, anterior margin $0.75 \times$ width of posterior margin, six setae along apical margin, the median pair $0.80 \times$ length neighboring more lateral setae, the outer pair nearly twice as long as more mesal neighbors. Maxillary palps with longer apical setae on second and third palpomeres, and sparse pelage of short microsetae over surface of palpomeres II–IV; palpomere IV fusiform, finely acuminate apically. Second labial palpomere with two longer anteromedial setae plus sparse pelage of fine microsetae. Mentum with acuminate median tooth; depressions of mentum deep, with pitlike foveae at deepest part; submentum with inner and outer pairs of lateral setae present. Antennae elongate; basal three antennomeres with sparse pelage of fine setae in addition to longer apical setae, the fine setae as long as pelage on antennomeres IV–XI; antennomere III slightly bowed posteriorly. Clypeus transverse, trapezoidal, anterior margin $0.70 \times$ length of posterior margin; one seta each side at middle of length. Eyes reduced to an obscurely faceted eyespot composed of four ommatidia, the ommatidial corneae flat, obscuring their margins (Fig. 2). Frons with broad, shallow, irregular frontal grooves, two supraorbital setae each side, anterior setae just above eyespot, posterior somewhat before neck constriction. *Prothorax*: pronotal lateral margins explanate, marginal bead depressed from front angle to mid-length, raised gradually to position of hind seta, gradually depressed posteriorly to hind angle; lateral margins evenly convex anterad hind setae, subparallel basad setae; hind angles right but bluntly rounded; median base with faint longitudinal wrinkles; basal marginal bead obsolete; median longitudinal impression foveate just anterad basal

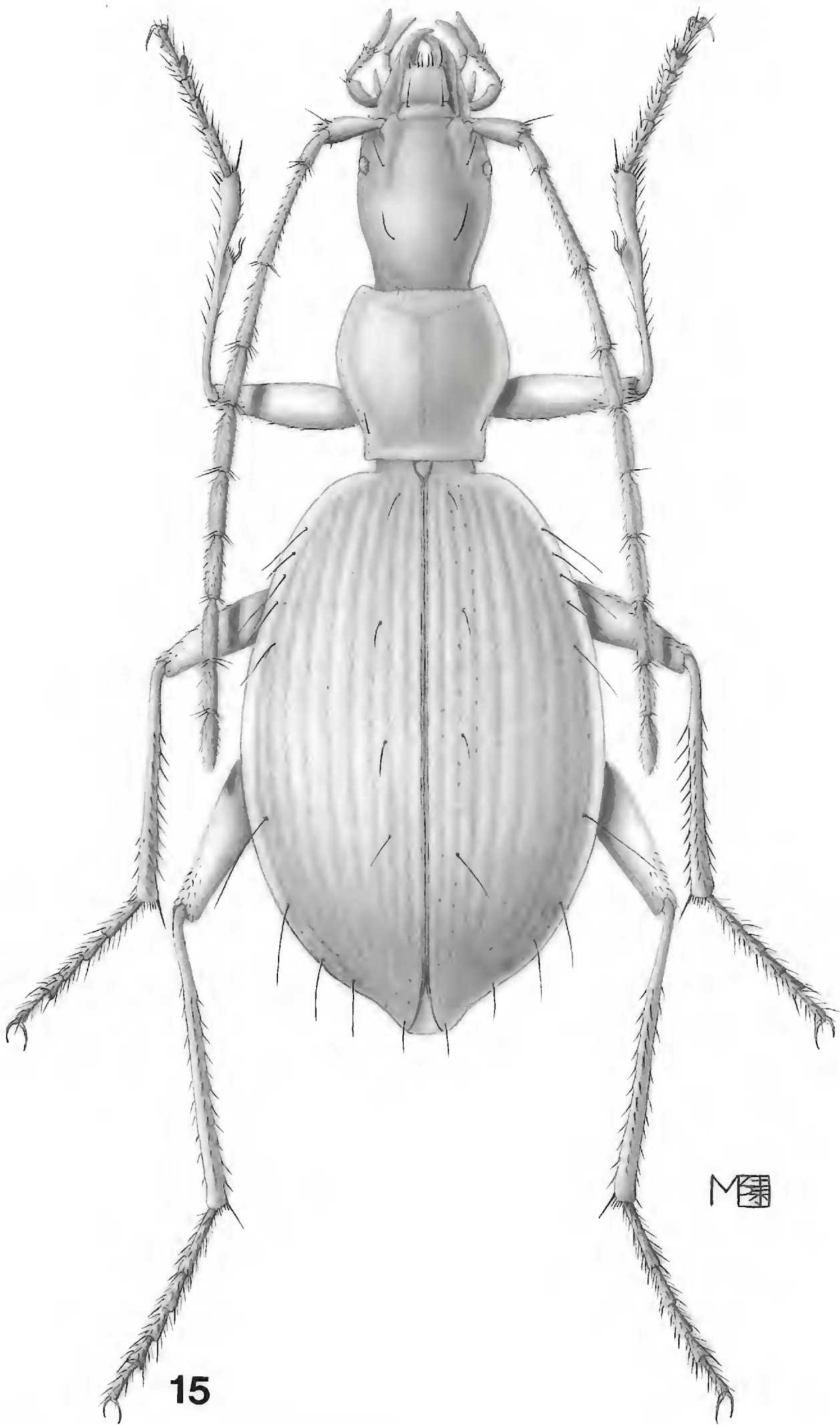
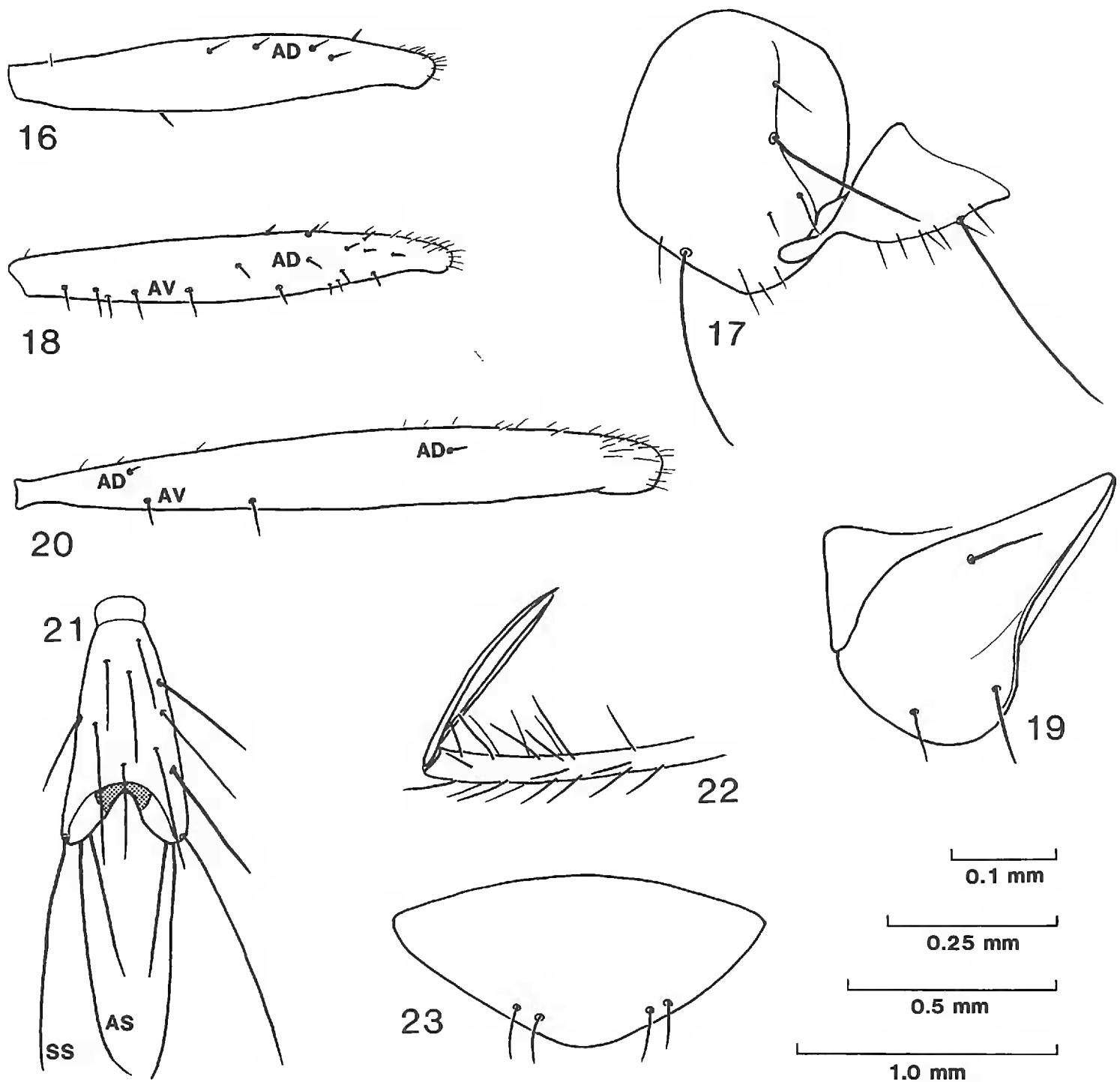
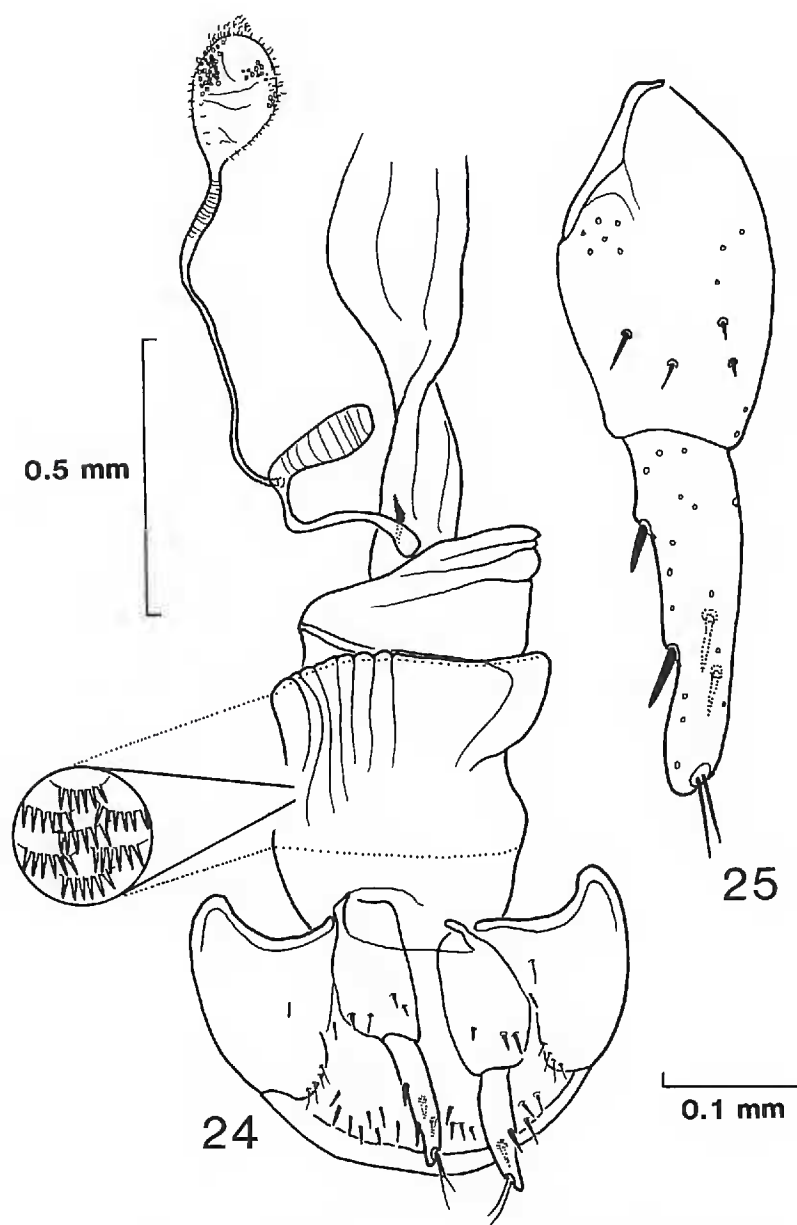


Figure. 15. *Atelothrus aaaa*, female holotype.



Figures. 16–23. *Atelothrus aaaa*. Figure 16. Left profemur (anterior view). Figure 17. Left mesocoxa and trochanter (anteroventral view). Figure 18. Left mesofemur (anterior view). Figure 19. Left metacoxa (ventral view). Figure 20. Left metafemur (anterior view). Figure 21. Right fourth metatarsomere (dorsal view; fifth tarsomere articular socket stippled). Figure 22. Left metapretarsus and claws (outer lateral view). Figure 23. Apical visible abdominal sternite of female (ventral view). Scale bar for Figs. 16, 18, 20, 23, 1.0 mm; for Fig. 19, 0.5 mm; for Figs. 17 and 22, 0.25 mm; for Fig. 21, 0.1 mm. AD = anterodorsal setae; AS = apical setae; AV = anteroventral setae; SS = subapical setae.

collar, fine near mid-length; anterior transverse depression deep, triangular medially, disappearing one-fifth distance to front angles; anterior margin with well-developed longitudinal wrinkles from middle to just inside lateral marginal depressions; anterior marginal bead obsolete; front angles slightly protruding, tightly rounded; lateral marginal depressions wide, of equal width along anterior half of notum, widened posteriorly to meet laterobasal depressions; basal seta positioned at basal 0.19 to 0.25 of length; weak carina extending medially from seta; laterobasal depressions smooth, with circular depression each side posterad basal setae. Prosternum depressed anterad procoxae, narrowly convex medially; prosternal projection with flattened ventral surface, ventral and posterior surfaces meeting at angulate apex; setae sparsely covering ventral surface. *Elytra*: form ovoid, humeri weakly developed, lateral margins nearly straight from rounded humeri to 0.40 of length, evenly convex posteriorly to well-developed subapical sinuation before rounded, protruding apex; basal groove faintly indicated inside fourth stria, evident and rounded on humerus; striae continuous, wavering basally, faintly punctate apically; intervals slightly convex; scutellar seta present; three dorsal elytral setae in third



Figures. 24–25. *Atelothrus aaaa*. Figure 24. Female external genitalia and reproductive tract (ventral view; circular detail shows cristate bursal scales that occur between dotted lines, each cristate scale approximately 0.01 mm across). Figure 25. Right gonocoxa (ventral view; dorsal ensiform setae on apical gonocoxite shown stippled). Scale bar for Fig. 24, 0.5 mm; for Fig. 25, 0.1 mm.

interval, the anterior seta in middle of interval narrowed at its position by coming together of striae two and three, the posterior two setae just laterad second stria; nine lateral setae adjacent eighth stria, five in basal half behind humerus, four in apical half before subapical sinuation; a single seta in apex of first elytral interval; lateral reflection wide from humerus to middle of length, narrower posteriorly, absent laterad subapical sinuation. *Pterothorax*: metepisternum slightly elongate, lateral margin $1.33 \times$ length of anterior margin; hind wings vestigial, small scalelike flaps much shorter than metepisterna. *Legs*: profemur elongate, slender, with one ventral seta, four anteroventral setae (Fig. 16), three posteroventral setae, and numerous fine setae apically. Mesocoxa with one larger ridge seta, one larger ventral seta, plus a sparse covering of fine setae, two of which are on mesocoxal ridge (Fig. 17); mesotrochanter with one large ventral seta and numerous short, fine setae over surface; mesofemur with approximately seven larger anteroventral setae, five anterodorsal setae, and numerous smaller setae along dorsal edge and on apical surfaces (Fig. 18). Metacoxa trisetose, inner seta present (Fig. 19); metafemur with two anteroventral setae, two anterodorsal setae, and numerous smaller setae along dorsal edge and apical surfaces (Fig. 20); basal three metatarsomeres with very shallow inner and outer dorsal sulci and a fine median carina, the dorsal surfaces of tarsi with a sparse pelage of microsetae; fourth metatarsomere convex dorsally, dorsal surface with sparse microsetae, subapical and apical setae present, apical margin medially emarginate with inner and outer lobes equally developed (Fig. 21); metapretarsus covered with sparse pelage of setae (Fig. 22). *Abdomen*: apical visible abdominal sternite of female with two setae on each side of apical margin (Fig. 23). *Microsculpture*: vertex with slightly transversely stretched isodiametric mesh, more transverse on constriction of neck. Pronotal disc with well-developed transverse mesh, more isodiametric mesh anterad anterior trans-

verse depression and on basal collar; laterobasal depressions with transverse mesh in deepest portions, mesh stretched parallel to lateral margin before hind setae. Elytral intervals with well-developed transverse mesh. Abdominal sternites with regular transverse mesh. *Color*: vertex yellow-brown, palps and antennal scape yellower, antennomeres II to XI brunneous. Pronotal disc slightly darker than vertex, anterior and lateral pronotal margins darker, brunneous. Elytra brunneous near scutellum, lighter, more flavous apically, translucent. Pronotal and elytral epipleura flavous; venter of body slightly darker, rufotestaceous. Coxae, trochanters, and femora flavous, concolorous with epipleura; tibiae and tarsi darker, concolorous with venter of body. *Body Size*: female holotype body length 7.05 mm. *Female Reproductive Tract*: bursa copulatrix elongate, with cristate scales lining the medial portion of the luminal wall (Fig. 24). Spermatheca tubular with short duct; spermathecal gland duct $2.0 \times$ length of spermathecal reservoir, entering at base of reservoir. Hemisternite IX with four setae along apical margin. Basal gonocoxite glabrous apically (Figs. 24 and 25), with several short setae on ventral surface. Apical gonocoxite narrow and elongate with rounded apex; two widely separated lateral ensiform setae (right side of holotype) or one lateral ensiform seta (left side), and two (right side) or one (left side) dorsal ensiform setae; apical depression bearing two nematiform setae.

Diagnosis.—Pronotum with single seta before base of lateral margin (Fig. 15); hind wings vestigial; eyes very small, obscurely faceted (Fig. 3); basal antennomeres, palps, and tarsi covered with sparse pelage of microsetae; humeri weakly developed; legs and antennae elongate, legs slender, antennae 5.0 mm long; body length 7.05 mm.

Etymology.—The species epithet signifies that this species has been found in lava tubes; 'a' a' ā being the Hawaiian word for lava tube.

Related Species.—The presence of a single pronotal lateral seta just before the hind angle, the dorsally bisulcate tarsomeres, and vestigial flight wings are sufficient to diagnose this species as an *Atelothrus*. *Atelothrus aaae* has diverged extensively in morphology relative to geographically proximate epigeal species. Its specializations typical of cave adapted taxa include elongation of legs and antennae, reduction of eyes, narrowing of the body, reduced melanization, and increased setosity (Casale 1988). We suggest that it is a member of the East Maui *Atelothrus* complex, but defer specifying a sister group pending comprehensive cladistic analysis. Based on its possession of symplesiomorphous character states of trisetose metacoxae and laterally bisetose female apical abdominal segment, *A. aaae* would not appear to be the sister taxon of *A. howarthi*, supporting two independent colonizations by *Atelothrus* species of the Kipahulu Valley caves.

Material Examined.—See type material.

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